

CEADRA2 Problemset 2.2

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1.) (10 pts.) Flow in a rectangular channel of width b takes place with a known depth y at velocity V . Downstream of this location there is an upward step of height h . Neglect losses, determine the channel width that must take place suddenly for critical flow to occur within the transition.

(a) $b = 2m$, $y = 2m$, $V = 3m/s$, $h = 30cm$

(b) $b = 10ft$, $y = 10ft$, $V = 10ft/sec$, $h = 2.3ft$

(5) $b = 3\text{m}$, $y = 3\text{m}$, $V = 3\text{m}^3/\text{s}$, $h = 70\text{cm}$
Solution:

$$h = 70\text{cm} = 0.7\text{m}$$

$$q = V/y = (3)(3) = 9\text{m}^2/\text{s} \quad A = b y \quad \Delta = (3)(3) = 9\text{m}^2$$

$$y_1 = 3\text{m}$$

$$y_c = \left(\frac{q^2}{g} \right)^{\frac{1}{3}} = \left(\frac{9^2}{9.81} \right)^{\frac{1}{3}} = 2.0211\text{m}$$

$$E_c = \frac{3}{2} y_c = 3.0317\text{m}$$

$$E_T = h + E_c = 3.7317\text{m}$$

$$E_1 = y_1 + \frac{q^2}{2gy_1^2}$$

$$E_1 = 3 + \frac{9^2}{2(9.81)(3)^2} = 3.4587\text{m}$$

$$Q = q b = (9)(3) = 27 \frac{\text{m}^3}{\text{s}}$$

$$\Delta A = A_1 - A_2$$

$$h_1 - h_2 = E_2 - E_1$$

Making the energy ^{level} position I equal to 0
 $E_T!$ $A = b_1, y_1$

$$E_T = \eta_1 + \frac{Q^2}{2\epsilon b_1^2 \eta_1^2}$$

$$3.7317 = 37 + \frac{27^2}{2(9.81) b_1^2 (2)^2}$$

$$b_1 = 2.3753 \text{ m}$$

$$\Delta b = b_1 - b = 3 - 2.3753 = -0.6247 \text{ m}$$

$$\Delta b = -0.62 \text{ m}$$

(27) $b = 16 \text{ ft}$, $y = 10 \text{ ft}$, $V = 10 \text{ ft}^3/\text{sec}$, $h = 2.3 \text{ ft}$
 solution:

$$q = Vy = (10)(10) = 100 \frac{\text{ft}^2}{\text{s}}$$

$$Q = qb = (100)(10) = 1000 \frac{\text{ft}^3}{\text{s}}$$

$$y_c = \left(\frac{Q^2}{g} \right)^{\frac{1}{3}} = \left(\frac{1000^2}{32.2} \right)^{\frac{1}{3}} = 6.77 \text{ ft}$$

~~$$E_c = \frac{3}{2} y_c = 10.158 \text{ ft}$$~~

where $E_1 = E_2$ $E_2 = 2.3 + 10.158 = 12.458 \text{ ft}$

$$A = b, y,$$

$$E_2 = y_1 + \frac{Q^2}{2g b^2 y_1^2}$$

$$12.458 = 10 + \frac{1000^2}{2(32.2)b^2(10)^2}$$

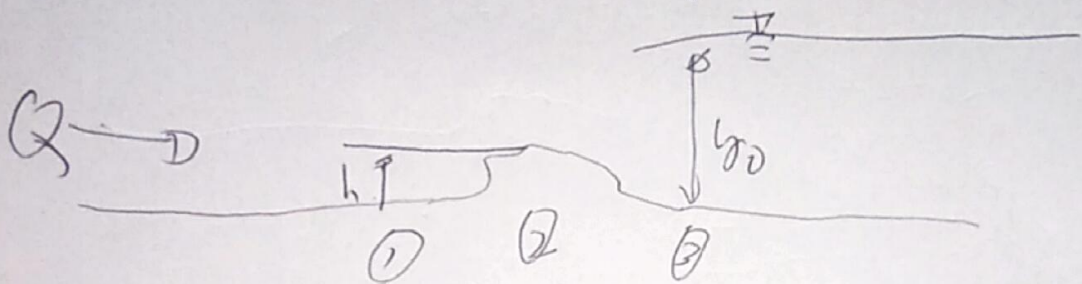
$$b_1 = 7.1482 \text{ ft}$$

$$E_1 = y_1 + \frac{Q^2}{2g y_1^2} = 10 + \frac{1000^2}{2(32.2)(10)^2} = 11.528 \text{ ft}$$

$$\Delta b = b_1 - b = 7.1482 - 10 = -2.0518 \text{ ft}$$

$$\Delta b = -2.05 \text{ ft}$$

2. (10 pts) Debris blocks the entire width of the river as shown. The cross-section of the river is approximately rectangular, where $b = 15\text{ m}$, $Q = 22.5\text{ m}^3/\text{s}$, $y_0 = 1.2\text{ m}$, and $h = 0.2\text{ m}$. Neglecting losses, analyze the rapidly varied water surface in the vicinity of the debris.



Solution:

$$q = \frac{Q}{b} = \frac{22.5}{15} = 1.5 \frac{\text{m}^2}{\text{s}}$$

$$y_c = \left(\frac{q^2}{g} \right)^{\frac{1}{3}} = \left(\frac{1.5^2}{9.81} \right)^{\frac{1}{3}} = 0.6121\text{ m}$$

$$E_c = \frac{3}{2} y_c = \frac{3}{2} 0.6121 = 0.9182\text{ m}$$

$$E_3 = y_0 + \frac{q^2}{2gy_0^2} = 1.2 + \frac{1.5^2}{2(9.81)(1.2)^2}$$

$$E_3 = 1.2796\text{ m}$$

$$E_T = h + E_2 = 0.27 + 0.9182 = 1.182 \text{ m}$$

$$h + E_2 = E_3 \Rightarrow E_2 = E_3 - h$$

$$E_2 = 1.2796 - 0.2 = 1.0796 \text{ m}$$

$$E_2 = y_2 + \frac{q^2}{2gy_2^2}$$

$$1.0796 = y_2 + \frac{1.5^2}{2(9.81)y_2^2}$$

$$y_2 = 0.3192 \text{ m}, 1.0025 \text{ m}$$

$$y_2 = 1.0025 \text{ m (since flow is subcritical)}$$

$$\text{Since } E_1 = E_2 = E_3 : y_0 = y_1 = y_3 = 1.2 \text{ m}$$

$$\begin{aligned} y_1 &= 1.20 \text{ m} \\ y_2 &= 1.00 \text{ m} \\ y_3 &= 1.20 \text{ m} \end{aligned}$$

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$$\text{For } E_3, E_3 = y_3' + \frac{q^2}{2gy_3'^2} \Rightarrow y_3' = 0.7515 \text{ m}$$

$$F_{r1} = \frac{\frac{q}{1.5}}{\sqrt{g h_1}} = \frac{\frac{1.5}{1.2}}{\sqrt{9.81(1.2)}} = 0.3643$$

$$F_{r2} = \frac{\frac{q}{h_2}}{\sqrt{g h_2}} = \frac{\frac{1.5}{1.0025}}{\sqrt{9.81(1.0025)}} = 0.4771$$

$$F_{r3} = F_{r1} = 0.3643$$